B1 cont'd

piece to cancel the non-uniformity of the static magnetic field. The other is active shimming that changes the current passed through a shim coil in response to uneven variation in the static magnetic field. One proposed active shimming ascertains the level of magnetic field non-uniformity by analyzing an NMR signal detected from the examined object, and controls the current passed through the shim coil based on this non-uniformity level. This is disclosed in, for example, U. S. Patent No.5530352.--

On page 3, replace the paragraph beginning "On the other hand," with the following paragraph:

B2

--On the other hand, in the method of reducing the magnetic field non-uniformity by using an NMR signal from the examined object, it is necessary to adjust the uniformity of the magnetic field after the object has been disposed in the magnetic field. This lowers the efficiency of the MRI examination. Further, the non-uniformity of the magnetic field is different depending on the part of the patient to be examined and the disposed position of the patient. Therefore, this method involves complex adjustments, and is incapable of efficiently overcoming the non-uniformity due to temperature variations.--

On pages 4 through 5, replace the paragraph beginning "According to the above aspect," with the following paragraph:

B3

--According to the above aspect, the magnetic field correcting unit is controlled based on a detected temperature. The non-uniformity of the static magnetic field is corrected based on this control. Therefore, it is possible to eliminate non-uniformity of the magnetic field due to temperature variations with good response. Accordingly, it is possible to cope with substantial variations in temperature or sudden changes in temperature. It is also possible to eliminated the need for a high-temperature bath for keeping the static magnetic field generating unit at a constant temperature. Therefore, a large space for disposing the object to be examined can be secured. This makes it possible to improve the efficiency of interventional work.--

On page 5, replace the paragraph beginning "Preferably," with the following paragraph:

B4 cont

--Preferably, the control unit controls the magnetic field correcting unit based on a temperature characteristic of the non-uniform component of the space distribution of the

B4 Cont'd

static magnetic field. The temperature characteristic of the non-uniform component can be ascertained in advance. The control unit calculates the non-uniform component at a detected temperature based on the detected temperature and the temperature characteristic, and controls the magnetic field correcting unit so as to generate an additional magnetic field that cancels the component.--

On page 6, replace the paragraph beginning "Further," with the following paragraph:

B5

--Further, according to a preferred embodiment of the MRI apparatus of the present invention, the temperature detecting unit detects temperatures of at least two positions including the static magnetic field generating unit and/or its surroundings. The temperature characteristic of the non-uniform component of the space distribution of the static magnetic field is obtained in advance for each temperature change at each position. The control unit calculates the non-uniform component at the detected temperature from the temperature detected at each position and the temperature characteristic. The control unit then corrects the magnetic field correcting unit so as to generate an additional magnetic field that cancels total non-uniformity of the respective positions.--

On pages 6 through 7, replace the paragraph beginning "According to another aspect" with the following paragraph:

B6

--According to another aspect of the present invention, there is provided a method for maintaining uniformity of a static magnetic field, which is a method of maintaining uniformity of a static magnetic field generated by a static magnetic field generating unit in an MRI apparatus, by generating an additional magnetic field. This method includes the steps of: obtaining a temperature dependence of a non-uniform component of a space distribution of a static magnetic field; detecting a temperature of the static magnetic field generating unit; and obtaining an intensity of the additional magnetic field based on the detected temperature and the temperature dependence.--

On page 11, replace the paragraph beginning "In the embodiment" with the following praragraph:

B7 Cont'd

--In the embodiment shown in Fig. 1, the thermometer 13 is disposed on the iron yoke 17 of the static magnetic field generating magnet 2, and detects the temperature of

the iron yoke. The shim coil 15 consists of one or a plurality of coils such as a coil that generates a magnetic field of a z term and a coil that generates magnetic field of xy term corresponding to a non-uniform component of the static magnetic field. Each shim coil 15 is disposed between the superconducting coils 16 and the gradient magnetic field coils 3. The gradient magnetic field coils 3 may also work as shim coils that generate a linear term correction magnetic field.--

B7 Cont'd

On page 11, replace the paragraph beginning "At first," with the following paragraph:

B8

--At first, a relationship between temperature and the non-uniformity of the magnetic field, that is, the temperature characteristic of the non-uniformity of the magnetic field is measured in advance. For measuring the temperature characteristic of the non-uniformity of the magnetic field, the magnitude of the non-uniformity (error magnitude) generated by change in temperature is measured for each component of each shim coil (step 27).--

On page 12, replace the paragraph beginning "Such ununiformity" with the following paragraph:

B9

--Such non-uniformity of the magnetic field is the sum of the non-uniformity of each component such as a linear term component of y (hereinafter to be referred to as y component) and a quadratic term component of z (hereinafter to be referred to as z^2 component). In the case of the y component, for example, the uniformity changes by approximately 6 ppm for a temperature change of 1°C, as shown in Fig. 4. The uniformity changes by approximately 3 ppm in the case of the z^2 component. At step 27, temperature characteristic is obtained for each non-uniformity component of the magnetic field (hereinafter to be referred to as error component) in advance.--

On page 13, replace the paragraph beginning "Then," with the following paragraph:

B10 Cont'd

--Then, a shim current that generates a correction magnetic field for canceling the change of the error component is calculated for each shim coil. This current is supplied to the shim coil (steps 31, 32). In the example shown in Fig. 4, when the temperature difference is + 1°C, the change of the error component of the z^2 component is 3 ppm. Therefore, when

the shim current that generates - 3 ppm (3/5 ampere in the above example) is applied to the shim coil of the z^2 component (shim characteristic 5 ppm/A), it is possible to cancel the non-uniformity of the static magnetic field attributable to the temperature variations.--

B9 Cont'd

On page 18, replace the paragraph beginning "In the above embodiment," with the following paragraph:

B11

--In the above embodiment, only the case of correcting the non-uniformity component of the magnetic field due to the temperature variations of the magnet has been explained. However, it may be performed together with the conventional active shimming method. The active shimming may be a method that detects NMR signals of the part of the object to be examined, analyzes the detected NMR signal, and applies a correction current to the shim coil to improve the uniformity of the magnetic field. Such an embodiment will be explained hereinafter with reference to Fig. 6.--

On pages 18 through 19, replace the paragraph beginning "In this embodiment" with the following paragraph:

B12

--In this embodiment, non-uniformity of the magnetic field due to temperature variations is corrected prior to the examination by the MRI apparatus (601 - 603). The temperature characteristic of each error component and shim characteristic of each shim coil are obtained in advance in a similar manner to that shown in Fig. 2. Before the examination, the temperature of the magnet is measured (601). The difference between the temperature at which the magnet achieves optimum uniformity of the magnetic field (reference temperature, for example 23°C) and the measured temperature is obtained. The magnitude of the error component of the magnetic field is calculated from the temperature characteristic of the error component obtained in advance (602). Next, a shim current that generates a correction magnetic field for compensating for the magnetic field error component is obtained, and this current is applied to the shim coil (603). At this stage, the thus obtained uniformity of the magnetic field is similar to the uniformity at the reference temperature.--

On page 20, replace the paragraph beginning "According to this embodiment," with the following paragraph:

B13 Cont'd

--According to this embodiment, it is possible to correct not only the non-uniformity of the magnetic field due to temperature variation of the magnet, but also the non-

uniformity of the magnetic field due to the influence of the magnetization factor of the examination area of the patient. Therefore, an MRI apparatus that achieves high uniformity of magnetic field can be provided. Using the MRI apparatus, a high-quality image can be obtained even when the imaging method requires high uniformity of the magnetic field, such as imaging in which only a fat signal is suppressed or an EPI.--

B13 Cont'd

On pages 21 through 22, replace the paragraph beginning "In the thus constructed" with the following paragraph:

B14

--In the thus constructed MRI apparatus, the process of maintaining the uniformity of the static magnetic field is similar to that shown in Fig. 2. First, the temperature characteristic of the magnetic field error component is measured (step 27), and the shim characteristic of the shim coil is measured (step 28). At step 27, when measuring the temperature characteristic of the magnetic field error component, the relationship between the temperature of an iron yoke 17 (static magnetic field generating magnet) and the magnetic field non-uniformity and the relationship between the difference of temperature between the iron yoke 17 and the connection pipe 19' and the magnetic field non-uniformity are obtained respectively in advance.--

On page 22, the paragraph beginning "Namely," with the following paragraph:

B15

--Namely, for the temperature of the iron yoke 17, the non-uniformity (error) generated due to temperature variation is measured for each component corresponding to the shim coil. Similarly, for variation in the temperature difference between the iron yoke 17 and the connection pipe 19', the non-uniformity (error) generated due to temperature variation is measured for each component corresponding to the component of the shim coil.--

On page 23, replace the paragraph beginning "The ununiformity" with the following paragraph:

B16

--The non-uniformity of the magnetic field attributable to the temperature variation is obtained as the sum of the following three factors: the non-uniformity of the linear term component of y (hereinafter referred to as y component), the quadratic term component of z (hereinafter referred to as z^2 component) and the quartic term component of z (hereinafter referred to as z^4 component). As shown in Fig. 9, when the temperature of the whole static magnetic field generating magnet 2 changes by 1°C, for example, the y

component changes by approximately 6 ppm, the z^2 component changes by approximately 3 ppm, and the z^4 component changes by approximately 0.5 ppm. On the other hand, as shown in Fig. 10, when the temperature difference between the iron yoke 17 and the connection pipe 19' changes, the y component changes by approximately -1.5 ppm, the z^2 component changes by approximately 6 ppm, and the z^4 component changes by approximately 3 ppm. As explained above, at step 27, the temperature characteristic of each non-uniformity component of the magnetic field (hereinafter referred to as an error component) is obtained in advance.--

B16 Cont'd

On page 24, the paragraph beginning "The shim current" with the following paragraph:

B17

--The shim current that generates a correction magnetic field for canceling the change of the error component is calculated for each shim coil. This current is then supplied to the shim coil (steps 31, 32). In the examples shown in Fig. 9 and Fig. 10, it is assumed that the temperature of the whole static magnetic field generating magnet 2 has increased by +1°C from the reference temperature 23°C, and the temperature difference between the iron yoke 17 and the connection pipe 19' is zero. In this case, the error component change of the z^2 component is 3 ppm. Therefore, a shim current that generates -3 ppm (3/5 ampere in the preceding embodiment) is applied to the shim coil of the z^2 (shim characteristic 5 ppm/A) so as to cancel the non-uniformity of the static magnetic field attributable to the temperature variations of the whole static magnetic field generating magnet 2. In this case also, provided that the shim coil characteristic of the z^2 is 5 ppm/A in a similar manner to that of the first embodiment, it is possible to cancel the non-uniformity of the static magnetic field attributable to the temperature characteristics, by applying the shim current of 3/5 ampere.--

On pages 24 through 25, replace the paragraph beginning "Another example" with the following paragraph:

B18

--Another example is now considered where the temperature of the space in which the static magnetic field generating magnet 2 is disposed has changed suddenly from the reference temperature 23°C to 25°C. Non-uniformity of the magnetic field in this case will be corrected immediately after this temperature change. The temperature of the iron yoke 17 is, for example, 23.5°C, which is close to 23°C. However, as the superconducting coil 16 and the connection pipe 19' are constructed of aluminum having a small thermal time constant, their temperature changes to 24.5°C. In this transient state, it is necessary to correct

B18 Cont'd

for a total of 8.5 ppm. This is the sum of the error component change of 1.5 ppm of the z^2 at 23.5°C shown in Fig. 9, and the error component change of 7 ppm of the z^2 due to the temperature difference 1°C between the iron yoke 17 and the connection pipe 19' as shown in Fig. 10. When the temperatures of the iron yoke 17 and the connection pipe 19' have become 25°C with passage of time, only the error component change of 6 ppm of z^2 is corrected based on Fig. 9.--

On page 31, replace the paragraph beginning "As explained" with the following paragraph:

B19

--As explained in the above, according to the present invention, the uniformity of the magnetic field is corrected based on changes in the temperature of the magnet or its surroundings. Therefore, it is possible to maintain the uniformity of the magnetic field at a high level. Particularly, when the temperatures of at least two positions are detected, it is possible to cope with complex and non-uniform temperature changes. As a result, the reliability of the MRI examination data can be increased. Further, according to the present invention, it is possible to efficiently correct only the non-uniformity of the magnetic field attributable to temperature variations, which reduces the imaging time.--

<u>IN THE CLAIMS</u>:

Please amend claims 5 and 8 to read as follows:

B20

5. (Amended) A magnetic resonance imaging apparatus according to claim 1, wherein the control unit comprises a voltage generating unit that generates a voltage corresponding to a non-uniformity component of the magnetic field at the temperature detected by the temperature detecting unit, a voltage/current converter that converts the voltage output by the voltage generating unit to current, and a supplying unit that supplies to the magnetic field correcting unit the current generated from the voltage/current converter.

B21 Cont'd

8. (Amended) A method of maintaining a static magnetic field generated by a static magnetic field generating unit uniform in a magnetic resonance imaging apparatus, by generating an additional magnetic field, the method comprising the steps of:

calculating a temperature dependence of a non-uniform component of a space distribution of the static magnetic field;

detecting a temperature of the static magnetic field generating unit; and